

## ANALYSIS OF THE NEED FOR GREEN OPEN SPACE (RTH) AS AN ABSORPTOR OF CARBONDIOXIDE GAS EMISSIONS IN THE SEMARANG-YOGYAKARTA NATIONAL ROAD CORRIDOR, BERGAS DISTRICT, SEMARANG REGENCY

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### ABSTRACT

*Semarang Regency is one of the areas in Central Java Province which has a variety of complex environmental problems, one of which is increasing carbon dioxide gas (CO<sub>2</sub>) emissions and the limited availability of green open space, especially in the Bergas District area. The increase in CO<sub>2</sub> gas emissions is due to the increasing trend of the population in Bergas District and this is directly proportional to the increasing number of ownership of motorized vehicle transportation. This study aims to examine the need for Green Open Space based on the ability of vegetation to absorb carbon dioxide (CO<sub>2</sub>) on the Semarang-Yogyakarta National Corridor Road, Bergas District, Semarang Regency, Central Java Province. Data collection in this study was carried out by traffic counting to calculate CO<sub>2</sub> emissions and field observations to calculate the absorption capacity of CO<sub>2</sub> emissions by vegetation. The results of this study indicate that the emissions produced by vehicles passing through the Semarang - Yogyakarta National Road corridor in Bawen District are 4,108,137.18 gr/hour, and emissions that can be absorbed by vegetation are only 642,846.47 gr/hour. So that the remaining emissions that have not been absorbed are 3,465,290.71 gr/hour. In order to optimally absorb the remaining emissions, at least 370 Swietenia mahagoni, 436 Pterocarpus indicus, 358 Samanea saman and 432 Bauhinia purpurea are needed.*

**KEYWORDS** *Green Open Space; Carbon dioxide gas emission; Environment*



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## INTRODUCTION

The increase in population from year to year causes population needs to also increase. To meet the needs of the population, residents tend to carry out activities in various sectors, such as the industrial, agricultural, transportation and household sectors. Daily activities such as activities within a household carried out by residents can directly cause an increase in the concentration of greenhouse gases in the air. The greenhouse gas that contributes the most to air emissions, namely around 77% of total GHG emissions, is carbon dioxide. Based on data from [Ministry of the Environment \(2012\)](#), increasing human activities are the main source of high CO<sub>2</sub> concentrations in the air. A significant increase occurred in the pre-industrial era, namely in the 1750s it was only 280 ppm and increased to 381 ppm in 2006. Carbon dioxide emissions are predicted to continue to increase between 0.3-2% per year, which will increase the earth's temperature by around 1o-5oC. This reality is driven by world economic developments which increase consumption of fossil fuels [Wikansari & Nurjani \(2021\)](#).

One effort that can be made to reduce the concentration of carbon dioxide in the air is to plant vegetation, especially trees. Various types of vegetation are able to absorb carbon dioxide because they need this gas for photosynthesis. Especially for urban areas, there are usually Green Open Spaces (RTH) which include city parks, natural tourist parks, recreational parks, residential and residential environmental parks, office and commercial building environmental parks, grand forest parks, city forests, protected forests, nature reserves, botanical gardens, zoos and others (Law Number 1 of 2007). Each 1 ha area of green open space has the capacity to absorb CO<sub>2</sub> produced by 2000 people or in other words, each person needs 5 m<sup>2</sup> of green open space ([Wikansari & S Nurjani, 2021](#)).

The increase in population also causes the change of undeveloped land into developed land. Residents need land to meet their daily needs, especially housing. Likewise with Tegalrejo District, where land use is dominated by residential areas with high household activity but the availability of green open space is very limited. Land that has not been developed, which is usually green land, can be useful for absorbing carbon dioxide through the process of photosynthesis by plants. These plants can be arranged in such a way as to become Green Open Space (RTH) which apart from its function of absorbing carbon dioxide can also provide other benefits. for the community such as play and recreation areas ([Handayani et al., 2020](#)).

One of the efforts made by the government to deal with global warming and create environmental sustainability is through the Green City Development Program (P2KH) with the development of Urban Green Open Space (RTHKP). RTHKP development can take the form of City Forests, City Green Belts, City Parks, Tourist Parks, Burial Grounds, yards, farms and plantations ([Lestari et al., 2012](#)). Based on government regulation no. 21 of 2021 concerning Implementation of Spatial Planning, minimum public green open space is 20% of urban areas and minimum private green open space is 10%. However, in reality, based on information from the Spatial Planning Division of the Semarang Regency Public Works Department (2021), there are still problems with achieving and juridical targets for the area of public green open space in Semarang Regency, in fact there are still several sub-districts where there are no parks or squares as one of them.

form of public green open space. Determining the percentage of green open space area is only a juridical approach and does not take into account its ecological function, as stated by others [Hariyanto \(2021\)](#) that green open space functions to improve air quality by converting CO<sub>2</sub> gas into O<sub>2</sub> which humans need.

Based on Law Number 11 of 2020 concerning Job Creation, Green Open Space (RTH) is an elongated/lane and/or clustered area whose use is more open, a place for plants to grow, both those that grow naturally and those that are deliberately planted taking into account aspects of ecological function, water absorption, economics, social culture and aesthetics. It is said to be 'green' because green open space is a place for plants to grow, either naturally or deliberately planted. Green open space has several functions, one of which is an ecological function; As is known, green open space is the 'lungs' of a city or region. Plants and greenery can absorb carbon dioxide (CO<sub>2</sub>), increase oxygen, reduce temperatures with shade and cool plants, become water catchment areas, and reduce noise (Green City Development Program, 2016).

Semarang Regency is one of the areas in Central Java Province which has a variety of complex environmental problems, one of which is increasing carbon dioxide (CO<sub>2</sub>) gas emissions and limited availability of Green Open Space ([Semarang Regency Environmental Service, 2018](#)). The increase in CO<sub>2</sub> gas emissions is due to increasing population trends in Semarang Regency and Average Daily Traffic on National Roads in Central Java Province. Increased CO<sub>2</sub> is not good for humans, humans need oxygen (O<sub>2</sub>) to breathe produces CO<sub>2</sub> and the same thing happens to motorized vehicles, that to burn fuel O<sub>2</sub> is needed and the exhaust gas produces CO<sub>2</sub>. This increase in carbon gas can result in air pollution and greenhouse gas effects which have an impact on global warming.

Bergas is one of the sub-districts in the Semarang Regency area with an area of ±4733 ha ([Semarang Regency Central Statistics Agency, 2021](#)). Based on research that has been carried out [Wardana & Pujiati \(2018\)](#), the area of public Green Open Space in Semarang Regency in 2015 was 529.52 Ha with a 1:2 green open space percentage (Public Green Open Space Area: Urban Settlement Area) of 7.68%. This figure is still far from the figure of 1377 Ha or 20% which is based on Law No. 11 of 2020 concerning Job Creation and Government Regulation No. 21 of 2021 concerning the Implementation of Spatial Planning.

The combustion residue from motorized vehicles consists of various dangerous substances that are released through the exhaust. The substances in question are Carbon Monoxide (CO), Carbon Dioxide (CO<sub>2</sub>), Nitrogen Oxide (NO or NO<sub>x</sub>), and Hydrocarbons (HC) which are produced from incomplete combustion of vehicles. The gas that often makes people faint is CO, even though it doesn't have the smell and color of other substances. Meanwhile, CO<sub>2</sub> is often a contributor to global warming, especially if the surrounding area lacks trees that can absorb it into oxygen (O<sub>2</sub>).

This research was conducted in villages in the Bergas District, Semarang Regency, which are crossed by the Semarang-Yogyakarta National Road corridor, namely 1.) Wujil Village, 2.) Karang Jati, 3.) Bergas Lor, 4.) Bergas Kidul, 5.) Jatijajar and 6.) Randugunting as can be seen from

Figure 1. Map Overview of Villages in Bergas District along the Semarang – Yogyakarta National Road. This was done because of the dense motor vehicle traffic passing through these villages.

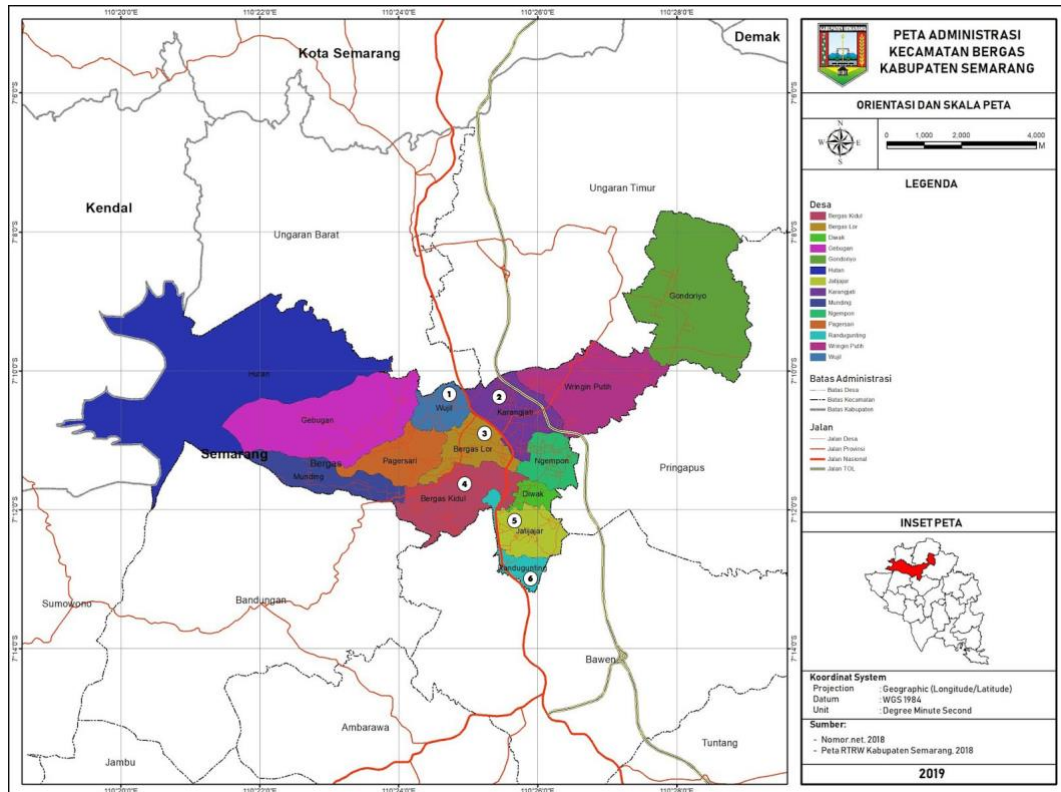


Figure 1. Map Overview of Villages in Bergas District along the Semarang – Yogyakarta National Road

Source: Semarang Regency Public Works Department, 2019

This research refers to research Wardana & Pujiati (2018) which analyzes strategies to increase public green open space in Semarang Regency, but this research places more emphasis on the ability of RTH vegetation to absorb carbon dioxide gas in Semarang Regency, especially in Bergas District. This research is limited to the use of carbon emissions through transportation activities, this is because as much as 70 percent of the use of carbon emissions is influenced by transportation activities. Thus, this research was conducted to provide an overview of the availability of green open space and the needs of plants to absorb CO2 emissions optimally.

Based on the background description above, it is known that the increasing number of residents and motorized vehicles every year has the potential to increase carbon dioxide (CO2) gas emissions which can cause air pollution. On the other hand, the availability of public Green Open Space (RTH) in Bergas District is still limited and the area of both private and public RTH in Bergas District is decreasing, initially in 2001 the area of green land cover in Bergas District was 3,777.10 Ha and in 2016 the area of green land cover in Bergas District decreased to 3,471.75 Ha.

The problem in this research is the decline in green open space in Bergas District by  $\pm 305.5$  ha or 20 ha per year, a decrease in the number of green open spaces followed by an increase in population and an increase in the number of motorized vehicles in Bergas District. It is known that the population in 2018 was 61.491 million people, in 2019 it was 62.281 million people and in 2020 it was 62.988 million people, while the number of motorized vehicles in Bergas District in 2018 was 5,998, in 2019 it was 6,371 and in 2020 it increased again to 6,996.

Based on data obtained from the Semarang Regency Environmental Service, it is known that the Green Open Space (RTH) in Bergas District is only a green belt and there is no city park. This raises the research question, namely "What is the need for vegetation in Green Open Space to be able to absorb CO<sub>2</sub> gas emissions optimally on the Semarang-Yogyakarta National Corridor Road, Bergas District, Semarang Regency?"

Based on the problem formulation that has been described, it can be seen that the aim of this research is to assess the need for Green Open Space (RTH) based on the ability of vegetation to absorb carbon dioxide (CO<sub>2</sub>) on the Semarang-Yogyakarta National Corridor Road, Bergas District, Semarang Regency, Central Java Province.

## RESEARCH METHOD

The research will be carried out on the Semarang-Yogyakarta National Corridor Road, Bergas District, Semarang Regency, Central Java Province in November 2022. The materials used in this research are motorbikes, cars (gasoline 4-wheeled vehicles), and buses and trucks (heavy vehicles diesel fuel) to find carbon dioxide (CO<sub>2</sub>) emission figures on the Semarang-Yogyakarta National Corridor Road, Bergas District, Semarang Regency. The next material is the vegetation in the green lanes of roads and parks in urban areas to determine the ability to absorb CO<sub>2</sub> emissions in green open spaces on the Semarang-Yogyakarta National Corridor Road, Bergas District, Semarang Regency.

Data collection in this research is divided into primary and secondary data. The primary data in this research are the number and type of motorized vehicles that use the national road in Bergas District as well as the number and type of vegetation in the green open spaces of Bergas District, Semarang Regency. In collecting data on the number and type of motorized vehicles, the traffic counting method was used during 3 days (2 working days and 1 holiday). Secondary data is a data source that does not directly provide data to data collectors, for example from other people or documents to support primary data needs (Sugiyono, 2008). Secondary data used in this research is data on the distribution of existing green open space, the Semarang Regency Administrative Map and the Semarang-Yogyakarta National Corridor Road. To obtain secondary data, this will be done by contacting the relevant agencies and conducting interviews, for example data on the distribution of existing green open space is sought from the Semarang Regency Environmental Service, Administrative Maps from the Semarang Regency Public Works Service.

Calculation of gas emissions CO<sub>2</sub> carried out in villages in Semarang Regency that pass through the Semarang-Yogyakarta National Road corridor, namely Wujil Village, Karang Jati, Bergas Lor, Bergas Kidul, Jatijajar and Randugunting. This was done because of the heavy motor vehicle traffic passing through these villages in Semarang Regency. The CO<sub>2</sub> gas emission value is obtained from the calculation formula for CO<sub>2</sub> gas emissions by means of transportation. In order to determine the need for vegetation in green open space, the remaining emissions at each observation point are calculated using the following formula (Pissera & Yulfiah, 2020): Remaining CO<sub>2</sub> Emissions = A – B, where A = Total CO<sub>2</sub> emissions (transportation equipment (gr/hour)); B = Total CO<sub>2</sub> absorption capacity by vegetation in green open space (gr/hour). After that, it will be known how much remaining CO<sub>2</sub> emissions have not been absorbed by the vegetation in the green open space in Bergas District, Semarang Regency. So from these figures we can design the green open space area so that it can absorb remaining CO<sub>2</sub> emissions optimally. Remote sensing techniques are the activity of identifying and analyzing objects or appearances using sensors at observation positions in the study area. The spatial study in this research was carried out to find out which points are felt to be necessary and can create Green Open Space (RTH) in the areas of villages that pass through the Semarang-Yogyakarta National Road Corridor, Bergas District so that it is hoped that it can reduce CO<sub>2</sub> gas emissions and meet the need for green open space in urban area of Bergas District, Semarang Regency.

## RESULT AND DISCUSSION

### Results' Analysis

#### *CO<sub>2</sub> emissions*

The amount of carbon dioxide emissions that can be calculated along the Semarang - Yogyakarta road, Bergas District, Semarang Regency, which is 5.6 km long, reaches 4,108,137.18 gr/hour, this result was obtained from the sum of the emissions from the three types of motorized vehicles, namely motorbikes, amounting to 1,221,600.68 gr/hour; cars amounting to 1,882,345.80 gr/hour; Buses and trucks amounted to 1,004,190.71 gr/hour. The advice given is that the government needs to issue a policy to suppress the use of private vehicles so that people can switch to mass transportation. Apart from that, the existence of green open space needs to be optimized in order to increase the ability to absorb CO<sub>2</sub>, considering that the tree density is still low.

#### *CO<sub>2</sub> Absorption by Vegetation*

The amount of CO<sub>2</sub> that can be absorbed by vegetation in green open space on the road Semarang – Yogyakarta, Bergas District, Semarang Regency shows the amount 642,846.47 gr/hour. These results were obtained from the sum of the total CO<sub>2</sub> emission absorption capacity by all types of vegetation according to Table 1. CO<sub>2</sub> Emission Absorption Capacity by Vegetation

**Table 1. Absorption Capacity of CO2 Emissions by Vegetation**

No	Vegetation Type	Amount	CO2 Absorption Ability	Total CO2 Emission Absorption Capacity (g/hour.tree)
1	Angsana	32	1,319.35	42,219.20
2	Mahogany	143	3,112.43	445,077.49
3	Mango	103	51.96	5,351.88
4	Fir	51	45.00	2,295.00
5	Cherry	46	0.60	27.60
6	Palm	105	0.39	40.95
7	Trembesi	8	3,252.10	26,016.80
8	Ketapang	53	24.16	1,280.48
9	Flamboyant	9	59.96	539.64
10	Banyan	21	1,146.51	24,076.71
11	Bamboo	360	0.39	140.40
12	Jackfruit	7	22.00	154.00
13	Glodokan	94	719.74	67,655.56
14	Star fruit	10	6.33	63.30
15	Guava	50	44.59	2,229.50
16	Sapodilla	2	96.90	193.80
17	Acacia	5	165.00	825.00
18	Red Shoot	124	155.58	19,291.92
19	Butterfly	2	1,331.38	2,662.76
20	Breadfruit	6	22.00	132.00
21	Sour	3	165.00	495.00
22	Teak	10	12.41	124.10
23	Bintaro	9	96.90	872.10
24	Cape	16	67.58	1,081.28
AMOUNT				642,846.47

Source: Author's Processed Data, 2023

The Semarang Regency Government needs to make efforts to reduce CO2 emissions in Bergas District. The form of management carried out by the government is in the form of: traffic engineering in Bergas District, providing green open spaces in road-owned spaces (Rumija), using BBG in BRT, carrying out periodic emission tests (especially on public transportation and heavy transportation), and implementing the blue sky program which in collaboration with Pertamina. However, the management carried out by the government is still not effective and optimal. If you look at the volume of vehicles crossing the roads in Bergas District, it has indeed decreased significantly, but there is still quite a large amount of CO2 remaining which has not been absorbed by plants. This CO2 accumulates for a long time, considering that CO2 gas can survive in the atmosphere for up to 200 years.

#### ***Evaluation of green open space for the Semarang-Yogyakarta National Road Corridor***

The remaining CO2 emissions amounting to 3,465,290.81 gr/hour can only be met if there are 370 Mahogany stems, 436 Angsana stems, 358 Trembesi stems and 432 Butterfly stems. Therefore, other alternative strategies are needed besides increasing the availability of Public Green Open Space in Bergas District. For

example, creating vertical gardens, optimizing public transportation facilities for the community and replacing vehicles that originally used fuel oil energy to become electrical energy.

#### ***Estimated CO2 Emissions in 2027 (next 5 years)***

The projection of the absorption capacity of green open space vegetation in Bergas District in 2027 is only 14 percent capable of being absorbed, while that which has not yet been absorbed is 86 percent, this shows that there is still a lack of vegetation capable of absorbing CO<sub>2</sub> until 2027. The increase in emissions also causes the need for plants and Green open space as an absorber of increased emissions. Based on the shortfall in emission absorption of 4,043,702.88 gr/hour, to be able to optimally absorb CO<sub>2</sub> emissions, at least 760 Butterfly plants, 767 Angsana plants, 325 Mahogany plants and 311 Trembesi plants need to be added. Apart from planting, it is necessary to maintain existing plants so that these plants remain sustainable and nothing dies.

#### **Discussion**

Vegetation that grows in green open space has a vital role as an absorber of CO<sub>2</sub> gas emissions in the air. According to Tinambunan (2015) in (Samsuri et al., 2021), a vegetation area can absorb CO<sub>2</sub> emissions of 58.2576 tonnes/year/ha. The projection of the absorption capacity of green open space vegetation in Bergas District in 2027 is only 14 percent capable of being absorbed, while that which has not yet been absorbed is 86 percent, this shows that there is still a lack of vegetation capable of absorbing CO<sub>2</sub> until 2027. The increase in emissions also causes the need for plants and Green open space as an absorber of increased emissions. Based on the shortfall in emission absorption of 4,043,702.88 gr/hour, to be able to optimally absorb CO<sub>2</sub> emissions, at least 760 Butterfly plants, 767 Angsana plants, 325 Mahogany plants and 311 Trembesi plants need to be added. Apart from planting, it is necessary to maintain existing plants so that these plants remain sustainable and nothing dies.

The existence of green open space is an important factor in maintaining ecosystem balance in urban areas. Ecological balance in urban areas must be taken into consideration as a barrier to physical development to prevent land destruction or conversion of productive land. Steps that can be taken to provide open space for absorbing carbon emissions are taking over ownership of dry land to convert it into green open space. The high value of CO<sub>2</sub> emissions could continue to increase if it is not immediately offset by the expansion of green open land as absorption areas. The effectiveness of absorbing CO<sub>2</sub> emissions can be increased by selecting plants with high absorption capacity such as Angsana and Trebesi. If the need for open land and plants with absorption capacity is met, CO<sub>2</sub> emissions can be reduced. Furthermore, if this concept is applied in all cities, global warming data is well addressed.

Changes are needed to planning strategies and a push for increased green space along the road as a whole will improve people's quality of life. There needs to be integration of more green space by planting more trees that have the ability to absorb very high CO<sub>2</sub> but with a short growing lifespan, such as the Angsana tree.



People should be concerned about the integration of more roadside green spaces because they are directly correlated with environmental health, promoting the sustainability of what will be lost from the natural environment due to the increasing activity of fossil fuel motor vehicles. To solve environmental problems, green spaces should be implemented on streets that have heavy activity. The main problems with populated environments and heavy motor vehicle activity are poor air quality due to traffic congestion and lack of open spaces for physical fitness and mental health. There is an increase in greenhouse gas emissions, especially carbon, in urban environments due to overcrowding of people and motor vehicles. Tree vegetation inside green spaces is beneficial for dense, congested areas because it helps reduce the amount of air pollutants released by motor vehicle exhaust. Parks along the way expose citizens to many air pollutants such as carbon. Green open spaces provide environmental health benefits to citizens by reducing exposure levels to air pollution largely from vehicle emissions. Green spaces that are low-carbon emission areas in carbon-rich areas allow for a healthier environment for citizens exposed to carbon and other air pollutants.

In Green Open Space Construction promotes the sustainable development of society by increasing 'carbon sinks' and reducing carbon sources. Green open spaces are areas that recycle and remove carbon in the atmosphere into oxygen and absorb other harmful air pollutants. In addition, green open spaces have been known to filter air, remove pollution, reduce noise because trees can reduce air pollution by absorbing certain air pollutants from the atmosphere.

Based on the results of calculating CO<sub>2</sub> absorption capacity by trees, tree absorption capacity is influenced by the number and type of trees. It can be concluded that overall green open space in Bergas District has not been effective in absorbing CO<sub>2</sub> gas emissions. Addition of green lanes along arterial and collector roads with ecological and aesthetic functions, especially as shade and absorbing air pollution. The development of green open space in Bergas District is like improving the quality of existing green open space by adding vegetation, especially shade. This area is directed to become a public green open space such as a residential neighborhood park which is facilitated with a play area, especially for social and aesthetic functions.

Ecosystem services in the form of provisioning are very influential in determining areas that have the potential for green open space development. Therefore, it is necessary to evaluate road green open space in the form of expanding green open space, planting tree species that have high CO<sub>2</sub> absorption capacity, reducing the frequency of use of motorized vehicles. Another alternative is greening the building with a roof garden or vertical garden, if there is no empty land. However, this action does not guarantee that it will eliminate all existing CO<sub>2</sub> gas emissions, but at least it can reduce CO<sub>2</sub> gas emissions that are widespread in Bergas District.

## **CONCLUSION**

Based on the research results obtained and discussed previously, it can be concluded that the required Green Open Space can absorb at least 4,043,702.88 gr/hour in 2027, which is the remaining emissions that have not been absorbed in

the Semarang - Yogyakarta National Road Corridor in the Bergas Area. To optimally absorb remaining emissions, at least 370 Mahogany stems, 436 Angsana stems, 358 Trembesi stems and 432 Butterfly stems are needed.

The strategy for developing regional green open space is to increase community participation and business actors to build green open space. Optimizing green open space on lines, road medians and river borders or increasing tree density and plant stratification is also recommended.

With the high remaining emissions obtained, to increase CO<sub>2</sub> absorption capacity, the provision of plants with high CO<sub>2</sub> absorption capacity but with a fast growth period must have a wider space to be grown along the road, for example the Angsana, Mahogany and Trebesi tree species.

Apart from that, other strategies are needed to reduce CO<sub>2</sub> emissions, such as optimizing public transportation facilities for the community and replacing vehicles that originally used fuel oil (BBM) energy into renewable electrical energy.

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